EXPLANATION OF DOE SAMPLING PLAN FOR CLASS A EXTERNAL POWER SUPPLIES

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1 INTRODUCTION

This document is intended to clarify the Department of Energy (DOE) sampling plan for Class A External Power Supplies (EPSs), which is based on the one-sided confidence limit.

Section 24(bb) of Title 10 of the Code of Federal Regulations (10 CFR) Part 430 states:

> For each basic model of external power supply selected for testing, a sample of sufficient size shall be selected at random and tested to ensure that—
>
> (1) Any represented value of the estimated energy consumption of a basic model for which consumers would favor lower values shall be no less than the higher of:
>
> (i) The mean of the sample, or
>
> (ii) The upper 97.5 percent confidence limit of the true mean divided by 1.05;
>
> and
>
> (2) Any represented value of the estimated energy consumption of a basic model for which consumers would favor higher values shall be no greater than the lower of:
>
> (i) The mean of the sample, or
>
> (ii) The lower 97.5 percent confidence limit of the true mean divided by 0.95.

To demonstrate compliance with EISA 2007 standards for Class A EPSs (in effect since July 1, 2008), manufacturers must: (1) Select a representative sample of units, (2) test them according to the DOE test procedure, and (3) certify the compliance of the EPS model(s) based on the test results of the sample, by submitting a compliance statement and the first certification report to DOE on or before July 6, 2010.

The remainder of this document provides additional background and an example of the application of the sampling plan. For further information, please consult the following sections of 10 CFR Part 430 (http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=02c69626033f84038e368435c8448b76&tpl=/ecfrbrowse/Title10/10cfr430_main_02.tpl):

- Energy conservation standard: Section 32(w) of 10 CFR Part 430
- Test procedure: Appendix Z to Subpart B of 10 CFR Part 430
- Certification requirements: Section 62 of 10 CFR Part 430
- Sampling plan: Section 24(bb) of 10 CFR Part 430
- Enforcement requirements: Sections 61, 71, 72, 73, and 74 of 10 CFR Part 430

- Example compliance statement and certification report: Appendix A to Subpart F of 10 CFR Part 430

2 EXPLANATION OF BASIC MODEL AND EPS DESIGN FAMILY

Manufacturers of consumer products covered by 10 CFR Part 430, must report the performance of each "basic model," which for EPSs is defined as:

> Basic model means all units of a given type of covered product (or class thereof) manufactured by one manufacturer and . . . With respect to external power supplies, which have electrical characteristics that are essentially identical, and which do not have any different physical or functional characteristics that affect energy consumption. Section 2 of 10 CFR Part 430.

However, because of the extent of customization within the EPS industry, manufacturers need only submit data on the lowest- and highest-voltage unit of each design family, which is a collection of basic models that share the same output power and fundamental design but may have different output voltages. Despite this reduced requirement, manufacturers would nonetheless be responsible for the compliance of all basic models within the design family. Similarly, manufacturers of switch-selectable EPSs need only submit data at the lowest- and highest-voltage setting.

3 EXPLANATION OF THE SINGLE-SIDED CONFIDENCE LIMIT

Section 24(bb) specifies that following each test, manufacturers calculate the 97.5-percent confidence limit of the theoretical mean, divided by a product-specific coefficient intended to reasonably reflect variations in materials, the manufacturing process, and testing tolerances. This limit specifies, with a given confidence, the probability that the theoretical mean of a normally distributed random variable will fall to one side of a given value. In other words, given a particular sample mean and distribution, the theoretical mean will fall above (in the case of average efficiency) or below (in the case of no-load power) the calculated limit 97.5 percent of the time.

Because the confidence limit estimate depends on the distribution test results, the number of test units in the sample necessary to certify compliance may be different with respect to the efficiency and no-load portions of the standard.

The equation for the lower confidence limit (LCL; used for reporting average efficiency) is:

$$LCL = X - \frac{t \cdot s}{\sqrt{n}},$$

while that for the upper confidence limit (UCL; used for reporting no-load power) is:

$$UCL = X + \frac{t \cdot s}{\sqrt{n}},$$

where:

X is the mean of sample
t is the value for 97.5% confidence from Table 1
s is the sample standard deviation
n is the number of units tested

The mean of the sample, X, is calculated as follows:

$$X = \frac{1}{n}\sum_{i=0}^{n} x_i,$$

where:

n is the number of units tested
x_i is the i^{th} test result
$\sum_{i=0}^{n} x_i$ is the sum of the results of n tests,

while the sample standard deviation, s, is calculated using the formula below:

$$s = \sqrt{\frac{\sum_{i=0}^{n}(x_i - X)^2}{n-1}},$$

where:

X is the mean of sample
n is the number of units tested
x_i is the i^{th} test result
$\sum_{i=0}^{n} x_i$ is the sum of the results of n tests.

Table 1. *t*-values for 97.5% confidence. Table is available from any statistics textbook or here: http://www.itl.nist.gov/div898/handbook/eda/section3/eda3672.htm.

n	$\sqrt{n}$	***t* for 97.5% confidence**
2	1.41	12.706
3	1.73	4.303
4	2.00	3.182
5	2.24	2.776
6	2.45	2.571
7	2.65	2.447
8	2.83	2.365
9	3.00	2.306
10	3.16	2.262

4 EXAMPLE OF CONFIDENCE LIMIT CALCULATION NECESSARY FOR COMPLIANCE CERTIFICATION

Now, assume that a random sample of EPSs must be tested to certify compliance with a standard of 85% average efficiency in active mode and 0.5 watts of input power in no-load mode.

4.1 Two Units in Sample

The process begins with the measurement of average efficiency in active mode and input power in no-load mode for two randomly-selected EPS units. The upper and lower confidence limits must then be calculated and compared to the respective sample means according to the criteria in section 24(bb) to determine whether the basic model is in compliance or non-compliance.

Table 2. Example EPS test results following measurements conducted on two randomly-selected units.

Test	**Active Mode Efficiency *%***	**No-Load Mode Power *W***
1	85.1	0.49
2	85.4	0.51

The results of tests of the first two randomly selected EPS units are listed in Table 2. At this point, $n = 2$, $t = 12.706$, the sample mean efficiency is 85.25% with a standard deviation of 0.2121%, and the sample mean no-load power is 0.500 watts with a standard deviation of 0.0141 watts.

Given this sample, the reported active mode efficiency would be no greater than the lower of the mean of the sample (*i.e.*, 85.25%) and the lower 97.5% confidence limit divided by 0.95, which is calculated as follows:

$$
\begin{aligned}
\frac{LCL}{0.95} &= \frac{X - \dfrac{t \cdot s}{\sqrt{n}}}{0.95} \\
&= \frac{85.25\% - \dfrac{12.706 \cdot 0.2121\%}{\sqrt{2}}}{0.95} \\
&= \frac{85.25\% - 1.906\%}{0.95} \\
&= 87.7\%.
\end{aligned}
$$

Therefore the reported efficiency shall be no higher than 85.2%.

Since the *t*-statistic decreases with the number of samples, while *n* increases, the 97.5% confidence limit estimate is likely to continue increasing with each subsequent test. Since both the estimate and the sample mean are greater than the active mode standard, the basic model is in compliance with the standard, and there is no need to continue testing the active mode efficiency.

Similarly, the reported no-load power would be no lower than the greater of the mean of the sample (*i.e.*, 0.500 watts) and the upper 97.5% confidence limit divided by 1.05:

$$
\begin{aligned}
\frac{UCL}{1.05} &= \frac{X + \dfrac{t \cdot s}{\sqrt{n}}}{1.05} \\
&= \frac{0.500\text{ W} + \dfrac{12.706 \cdot 0.0141\text{ W}}{\sqrt{2}}}{1.05} \\
&= \frac{0.500\text{ W} + 0.127\text{ W}}{1.05} \\
&= 0.60\text{ W}.
\end{aligned}
$$

Therefore, the reported no-load power shall be no lower than 0.60 watts.

Even though the mean of the sample is 0.50 watts, the upper confidence limit estimate is higher at 0.60 watts due to the small number of samples. Because the estimate is greater than the mean, additional samples must be tested to determine whether the basic model is in compliance.

4.2 Three Units in Sample

Since the basic model was determined to be in compliance following two tests, no further active mode tests were conducted. The result of the third no-load test is shown in Table 3. Following this test, $n = 3$, $t = 4.303$, and the sample mean no-load power is 0.507 watts with a standard deviation of 0.0153 watts.

Table 3. Example EPS test results following measurements conducted on two randomly-selected units.

Test	Active Mode Efficiency %	No-Load Mode Power *W*
1	85.1	0.49
2	85.4	0.51
3	–	0.52

The reported no-load power would be no lower than the greater of the mean of the sample (*i.e.*, 0.507 watts) and the upper 97.5% confidence limit divided by 1.05:

$$
\begin{aligned}
\frac{UCL}{1.05} &= \frac{X + \dfrac{t \cdot s}{\sqrt{n}}}{1.05} \\
&= \frac{0.507\ \mathrm{W} + \dfrac{4.303 \cdot 0.0153\ \mathrm{W}}{\sqrt{3}}}{1.05} \\
&= \frac{0.507\ \mathrm{W} + 0.0380\ \mathrm{W}}{1.05} \\
&= 0.52\ \mathrm{W}.
\end{aligned}
$$

Therefore, the reported no-load power estimate shall be no lower than 0.52 watts. Since the upper-confidence limit estimate is still higher than the mean of the sample, further tests must be conducted to determine compliance or non-compliance. In general, a limited number of randomly selected units can be tested as non-compliant; these can be considered to be intermediate results if continued testing leads to the greater of the sample mean or the UCL divided by 1.05 falling within the standard.

4.3 Four Units in Sample

Finally, the result of the fourth no-load power test is shown in Table 4. Following this test, $n = 4$, $t = 3.182$, and the sample mean no-load power is 0.513 watts with a standard deviation of 0.0171 watts.

Table 4. Example EPS test results following measurements conducted on two randomly-selected units.

Test	Active Mode Efficiency %	No-Load Mode Power *W*
1	85.1	0.49
2	85.4	0.51
3	–	0.52
4	–	0.53

With four measurements in the sample, the reported no-load power would be no lower than the greater of the mean of the sample (*i.e.*, 0.513 watts) and the upper 97.5% confidence limit divided by 1.05:

$$
\begin{aligned}
\frac{UCL}{1.05} &= \frac{X + \frac{t \cdot s}{\sqrt{n}}}{1.05} \\
&= \frac{0.513\ \mathrm{W} + \frac{3.182 \cdot 0.0171\ \mathrm{W}}{\sqrt{4}}}{1.05} \\
&= \frac{0.513\ \mathrm{W} + 0.0272\ \mathrm{W}}{1.05} \\
&= 0.51\ \mathrm{W}.
\end{aligned}
$$

Therefore the reported no load power can be no lower than 0.51 watts.

After four tests, the confidence limit estimate is equal to the sample mean. Although the confidence interval estimate is likely to continue decreasing with further tests, the sample mean is greater than the no-load power specified by the standard. While testing of additional units can be performed, the sample mean is unlikely to decrease further. Therefore, this hypothetical basic model would be considered non-compliant with the standard and could not be sold in the United States.